SHARKS IN THE NATIONAL PARK SYSTEM:

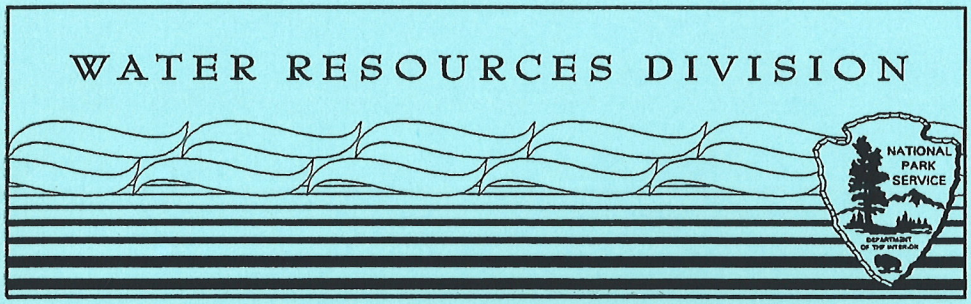
STATUS, CONSERVATION, AND MANAGEMENT OPTIONS

Rita A. Bruckler

and

Frank M. Panek

Technical Report NPS/NRWRD/NRTR-96/92



National Park Service - Department of the Interior
Fort Collins - Denver - Washington

United States Department of the Interior ◆National Park Service

The National Park Service Water Resources Division is responsible for providing water resources management policy and guidelines, planning, technical assistance, training, and operational support to units of the National Park System. Program areas include water rights, water resources planning, regulatory guidance and review, hydrology, water quality, watershed management, watershed studies, and aquatic ecology.

Technical Reports

The National Park Service disseminates the results of biological, physical, and social research through the Natural Resources Technical Report Series. Natural resources inventories and monitoring activities, scientific literature reviews, bibliographies, and proceedings of technical workshops and conferences are also disseminated through this series.

Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the National Park Service.

Copies of this report are available from the following:

National Park Service (303) 225-3500
Water Resources Division
1201 Oak Ridge Drive, Suite 250
Fort Collins, CO 80525

National Park Service (303) 969-2130
Technical Information Center
Denver Service Center
P.O. Box 25287
Denver, CO 80225-0287

SHARKS IN THE NATIONAL PARK SYSTEM:

STATUS, CONSERVATION, AND MANAGEMENT OPTIONS

Rita M. Bruckler
American Fisheries Society

and

Frank M. Panek
Water Resources Division
National Park Service

Technical Report NPS/NRWS/NRTR-96/92

October 1996

United States Department of the Interior
National Park Service

Table of Contents

LIST OF TABLES

EXECUTIVE SUMMARY

Sharks are important predators in the marine environment. They are also particularly sensitive to excessive exploitation because of their slow growth, late maturation, and small brood size. Recent scientific and popular accounts suggest that many shark populations in the Atlantic Ocean and along the Pacific Coast have been depleted. More than 40 national park units have marine resources in which sharks may occur as juveniles or adults. Given the preservation goals of the National Park Service, park-resource managers must be aware of possible threats to sharks and must consider the protection of sharks in management and operational planning.

In this report, we summarize the current information about shark populations and the causes of population depletion, and we present management options for consideration by park-resource managers.

Management options:

- closure of shark nurseries to fishing or boating,
- closure of shark mating areas to fishing or boating,
- protection of habitat in nursery areas,
- prohibition or restriction of shark fishing in park waters,
- prohibition of finning in Pacific parks, and
- increased enforcement of federal and state regulations.

Additional research and information are needed about the effects of environmental degradation and human activities on shark populations and the relations between the occurrences of sharks and annual sportfishing harvests in some park waters. Research topics such as the determination of abundance and distribution of sharks in park waters, the identification of mating and nursery areas, and the monitoring of the effects of environmental factors are suggested in this report. Specific research needs should be addressed by park managers in park-specific Resource Management Plan Project Statements.

INTRODUCTION

Sharks are important apex predators in the marine environment (Wetherbee et al. 1990). Their life history patterns, which are characterized by slow growth, large adult size, late sexual maturity, and few offspring, render sharks more vulnerable than teleosts or bony fishes to excessive exploitation. In the Atlantic and Pacific oceans, shark populations are showing the effects of high fishing pressure. Once depleted, stocks may require a long recovery period and some species may require decades for full recover.

Some marine waters in or adjacent to national park units support recreational or commercial shark fisheries. In addition, human activities, such as fishing and boating, can interfere with shark mating and the feeding by juveniles. This has necessitated the closure of breeding and nursery grounds of nurse sharks (Ginglymostoma cirratum) in certain park waters (Carrier 1996; Carrier and Pratt 1996). Because of the preservation mission of the National Park Service, measures by park-resource managers for the protection of these animals is important. Activities under National Park Service jurisdiction must not contribute to the depletion of sharks.

In this report, we summarize the current information about shark populations and the causes of population depletion, and we present management options for consideration by park resource managers.

COMMERCIAL AND RECREATIONAL FISHERIES

Sustained intensive commercial fishing of sharks is a recent phenomenon. Short-lived shark fisheries in the 1930s and 1940s were fueled by a high demand for vitamin A from shark liver. The availability of synthetic vitamin A and the low demand for other shark products caused these fisheries to end in about 1950 (Springer 1951).

In the early 1960s, Norwegian fishers began exploiting porbeagles (Lamna nasus) off the U.S. Atlantic Coast. The porbeagle catch increased from 1,800 to 9,300 metric tons (mt) between 1961 and 1964 but declined to 200 mt several years later (Casey et al. 1978). Within a few years, this relatively small shark fishery collapsed because of excessive harvest. Thirty years later, the porbeagle population still has not fully recovered (NOAA 1993). This and other examples have demonstrated the inability of sharks to sustain intensive exploitation (Anderson and Teshima 1990).

Commercial shark fishing again increased in the 1980s because of domestic demand for shark meat and foreign demand for shark fins, which are used for shark-fin soup in Asia. Commercial landings were low in 1979 (135 mt) but rapidly increased in the mid-1980s--surpassing increasing recreational landings--and peaked in 1989 at 7,122 mt (Table 1)(NOAA 1993).

The high price of shark fins led to the wasteful practice of *finning*, that is, removing the fins and discarding the carcass. Finning is now prohibited in waters of the United States and in most state-

controlled waters in the Atlantic Ocean and in waters of California in the Pacific Ocean. On the East Coast, the preferred sharks for the fin-soup market are in order of preference: sandbar (Carcharhinus plumbeus) and bull (C. leucas) sharks, hammerheads (Sphyrna spp.), blacktip shark (C. limbatus), porbeagle (Lamna nasus), mako (Isurus spp.), thresher (Alopias vulpinus), and blue shark (Prionace glauca).

Longlines or gillnets are mainly used in the directed commercial shark fisheries. Longline fishers mainly catch sand tiger (Odontaspis taurus), bignose (Carcharhinus altimus), spinner (C. brevipinna), bull, blacktip, sandbar, tiger (Galeocerdo cuvieri), and lemon sharks (Negaprion brevirostris), scalloped hammerhead (Sphyrna lewini), and great hammerhead (S. mokarran) Bonfil 1994). Gillnet fishers operate mainly from May to November when sharks are in shallow waters and often fish in known nurseries. They catch sand tiger, blacknose (Carcharhinus acronotus), spinner, finetooth (C. isodon), bull, dusky (C. obscurus), sandbar, and sharpnose (Rhizoprionodon spp.) sharks, scallopped hammerhead, and others. Some states banned the use of commercial gillnets in their waters (NOAA 1993).

Incidental catches of sharks occur in the tuna (Scombridae) and swordfish (Xiphias gladius) longline fisheries and in some shrimp fisheries. Blue shark, porbeagle, hammerhead, and other sharks are incidental or by-catches in the tuna fishery. The largest incidental catch rate is of blue shark and estimated to be about 40 percent of the total catch in some fisheries (Bonfil 1994). In the swordfish fishery, incidental catches of threshers, makos, and others (probably bignose, silky [C. falciformis], dusky, night [C. signatus], and blue sharks) are common. Large numbers of Atlantic sharpnose sharks (Rhizoprionodon terraenovae) and juveniles of several other species are taken by shallow-water shrimp trawlers. Shrimping is common in some nurseries, and many juvenile sharks are caught incidentally. The mortality of sharks in trawls and gillnets is nearly 100 percent (Bonfil 1994).

Recreational fishing for sharks became popular in the early 1970s, and many sharks caught in tournaments were discarded. Landings in the Atlantic recreational shark fishery reached 11,512 mt in 1979 before they declined steadily to 1,666 mt in 1989 (Table 1)(NOAA 1993). Recreational landings were about 16 percent of the average total annual landings of large coastal species during 1986-91 (Parrack 1992). Most recreational shark fishing is done from small to medium-size boats rather than from shore or piers (Hoff and Musick 1990), although some of these latter fisheries can be locally significant.

BIOLOGY

Most sharks are migratory. They move in pursuit of prey, for reproduction, or in response to environmental factors such as temperature, light, or oceanic currents (Castro 1983). The migration may cover short distances as, for example, in nurse sharks (Carrier 1996) or cover an annual route of thousands of kilometers as in many of the pelagic species. In many species, these migrations are related to reproductive cycles.

Ovoviviparity or aplacental viviparity is the most common type of reproduction in sharks (Castro 1983). After internal fertilization, which occurs in all sharks, the eggs hatch in the uterus and absorb the rich yolk as they continue to develop. This form of reproduction occurs in some nurse, thresher, and angel (Squatina californica) sharks. Oviparity, the release of fertilized eggs, occurs in only four families including some nurse sharks and whale sharks (Rhincodon typus). Viviparity or placental viviparity, in which the young hatch internally and develop a placental connection to the mother, occurs in some smooth dogfishes (Mustelus canis), in the requiem sharks (Charcharhinidae), and in the hammerhead sharks.

The brood size in sharks tends to be small, usually ranging from 2 to 25 (NOAA 1993). The young are generally large at birth, and therefore the number of their potential predators is not as large as that of other species. The duration of the ovarian cycle is usually about one year but may be two years in some species. The duration of gestation is about one year. After mating, the females of most species travel to specific nurseries to give birth, usually in spring or summer (Castro 1993a).

In general, sharks pup, or give birth, from spring through summer and possibly into early fall. The specific season of parturition of some species in certain nurseries has been determined. For example, Atlantic sharpnose sharks off the coast of South Carolina give birth from the last week of May to the second week of June, and gravid bull sharks seemingly enter the Indian River lagoon system in Florida to give birth from May to July (Castro 1993a).

Shark nursery area are geographically discrete, typically in shallow coastal waters where gravid females go to deliver young or deposit eggs and where the juvenile sharks spend their first weeks or even years of life (Castro 1993a). It has been suggested that females tend to select areas with few large sharks, making humans the only predators of juvenile sharks (Springer 1967). Nurseries are generally located in highly productive ecosystems where invertebrates and small fishes provide abundant food for the young sharks (Schmidt 1986). Such areas include coastal marshes and estuaries or seagrass beds and mangrove habitats (Castro 1993a).

Falling temperatures in fall often force juveniles to migrate south to warmer waters. This extends nurseries to larger geographic areas and to more than one type of habitat. However, little information is available on most winter nurseries (Castro 1993a). For some species, broad geographic areas including nurseries have been identified. For example, the nurseries of the Atlantic sharpnose shark seem to be from central Florida to North Carolina, and the nurseries of the sandbar shark lie in Atlantic coastal waters from Long Island to Cape Canaveral (Castro 1993a). The nurseries of several species in the southeastern United States have been more specifically delineated. For example, Bulls Bay in South Carolina serves as a nursery for several species including the blacktip, dusky, sandbar, and Atlantic sharpnose sharks (Castro 1993a). Nurseries of the lemon shark seem to be located from southern Florida to the Bahamas, and newborn lemon sharks have been caught from May through July in the Florida and Biscayne bays (Schmidt 1986; Wright 1981), whereas newborn nurse (Ginglkymostoma cirratum), blacktip, and bonnethead (Sphyrna tiburo) sharks have been caught in the Florida Bay during the summer months (Thomas Schmidt, personal communication). However, many nurseries are yet to be

identified on the Atlantic and Pacific coasts.

Human activity or environmental degradation that may drive juvenile sharks or females about to give birth away from the nurseries and into areas with more predators may harm the population. Habitat degradation can also affect sharks by reducing the availability of prey species (NOAA 1993). Although the effects of various forms of habitat degradation on shark populations have not been clearly determined, habitat loss is thought to have caused the disappearance of sandbar sharks from the Venice area of the northern Adriatic Sea (Oliver 1996). Forms of environmental degradation that are of concern are the destruction of coastal wetlands, bays, mangroves, coral reefs, kelp forests, and benthic areas; alteration of freshwater inflows to estuaries; and general water-quality degradation from many anthropogenic activities such as dredging, discharge of contaminants, and poor land-use practices (NOAA 1993; Oliver 1996).

Closure of nurseries to fishing during the pupping season has been suggested as a management strategy to increase the probability of recovery of some species (NOAA 1994). Whether other anthropogenic activities, such as boating or swimming, would measurably affect sharks in nurseries has not yet been determined.

In general, sharks grow and mature slowly. Some of the commercially important sharks in the family Carcharhinidae, such as sandbar sharks, do not reach maturity until 12 to 18 years of age (Table 2). Slow growth, late maturation, and small brood size make shark populations particularly vulnerable to overfishing. Recent evidence suggests that recruitment overfishing is a common problem to most marine finfish stocks (Myers and Barrowman 1996).

STATUS OF SHARK POPULATIONS

There are numerous indications that shark populations in the Atlantic Ocean and coastal Pacific Ocean have been affected by increased fishing pressure, but assessments of the extent of the effect and the time required for recovery have been difficult (NOAA 1995; Holts 1988). The highly migratory nature of many shark species complicates stock assessment. In addition, information gaps about age at maturity, fecundity, and mortality present problems in predicting recovery time.

Several shark species, including sand tiger, basking (Cetorhinus maximus), blacktip, dusky, and sandbar sharks, and porbeagle, have been placed on the World Conservation Union's Red List of Threatened Animals (Baillie and Groombridge 1996). In addition, certain shark species, especially those in the Carcharhinidae family, are being considered for inclusion in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendixes (Oliver 1996). If listed, the recreational harvest will probably not be affected, but effects on the commercial trade of parts and products from these sharks may be far-reaching. To date, no sharks have been listed as endangered or threatened under 50 CFR 17.11 (Endangered and Threatened Wildlife) by the National Marine Fisheries Service.

Atlantic Populations

For management, Atlantic shark populations are divided into three groups: large coastal, small coastal, and pelagic sharks (Table 3)(NOAA 1993). The coastal sharks inhabit nearshore areas and continental shelves. The large coastal group includes blacktip, dusky, and lemon sharks, and the small coastal group includes Atlantic angel (Squatina dumerili) and sharpnose sharks. The pelagic sharks range widely in upper zones of the ocean and may travel over the entire ocean basin. This group includes makos, oceanic whitetip sharks (Carcharhinus longimanus), and blue sharks. Deep-dwelling sharks, such as cat sharks (Apristurus spp.) and gulper sharks (Centrophorus spp.), inhabit the cold waters of the continental slopes and ocean basin and will not be considered in this report.

The abundance of small coastal sharks has been relatively stable, and even a slight increase occurred since 1986 in Atlantic sharpnose populations (NOAA 1995). They do not seem to be excessively exploited but may be fully exploited. However, small coastal sharks, usually juveniles, are often taken incidentally in the shrimp fishery. The effects of incidental catches and of the destruction of nurseries on the small coastal group of sharks is not yet clear.

Decreases in the commercial catch per unit effort (CPUE) of large coastal and pelagic sharks were profound from the early 1970s to the mid-1980s. The CPUE of large coastal sharks alone dropped to 15-35 percent of the 1970s level (NOAA 1995). In addition, a fishery independent CPUE evaluation of large coastal sharks off the coast of Virginia showed a 9.3 percent decrease per year during 1980-1985 (NOAA 1994). The downward trend in CPUE continued through 1991, indicating further depletion of stocks. CPUE data since 1991 have been variable and do not offer strong evidence of rebuilding of the stocks. Recovery to the 1970s level is expected to be slow and may require 30 years or longer (NOAA 1995).

The popularity of recreational shark fishing has increased as shown by the increasing number of shark tournaments in the Northeast (10 in 1980 to 45 in 1985), which may take 10-15 metric tons of sharks each year (Hoff and Musick 1990). More than two-thirds of the recreational catch is made from boats. The dominant species in the Atlantic recreational fishery is the shortfin mako (Isurus oxyrinchus), but many dusky, sandbar, and blue sharks are also caught (Hoff and Musick 1990). A recent decline in the number of shark tournaments in the Florida Keys may be linked to declining shark abundances (Thomas Schmidt, personal communication).

Pacific Populations

Several shark species are targeted in the commercial shark fishery in the Pacific Ocean off the western continental United States (Table 4). These include the soupfin shark (Galeorhinus galeus), shortfin mako, thresher shark, Pacific angel shark (Squantina californica), spiny dogfish (Squalus acanthias), and leopard shark (Triakia semifasciata). The leopard shark is also popular in the recreational fishery. Although not a targeted species, blue sharks are incidental catches in the thresher shark fishery.

In general, shark landings on the West Coast increased through 1985 but have declined since then (Oliver 1996). Landings of the common thresher in California peaked in 1982 and have since declined (Holts 1988; Stick et al. 1990). Fishing pressure on the angel shark is greatest around the Channel Islands, and sufficiently large quantities for fishing do not seem to exist very far north or south of the islands (Holts 1988). No fisheries in the western Pacific Ocean, including American Samoa, Guam, and Hawaii, target sharks, but blue sharks are taken incidentally in other fisheries and are a large percentage of the catch (Bonfil 1994; Leslie Ann McGee, personal communication).

Leopard shark, spiny dogfish, thresher, shortfin mako, and blue shark are some of the species targeted by anglers in the Pacific Ocean. According to a survey by the National Marine Fisheries Service, angler effort for thresher shark, shortfin mako, and blue shark increased by a factor of ten from 1986 to 1989 (Cailliet et al. 1993). Shark tournaments have retained their popularity in southern California where about 6-10 are scheduled each year. The catches of shortfin mako and blue shark averaged 204 mt/year and 2,835 mt/year respectively between 1989 and 1993 (David Holts, personal communication). In California, the average annual catch of sharks in the recreational fishery increased from 15 mt in 1958-61 to 150 mt in 1981-86 and was 0.3 percent of the total marine recreational fishery (Karpov et al. 1995). The number of sharks caught during 1981-86 was divided about equally between near-shore fishing (pier, beach, jetty, and bank) and fishing from boats, and leopard sharks were the greatest near-shore catch (Karpov et al. 1995).

Recreational shark fishing is thought to have contributed to the decline of dusky shark populations in the early 1980s (Musick et al. 1993). Today, many states have bag limits for sharks and require live releases of sharks that cannot be kept. The effects of current levels of recreational fishing and the effectiveness of management regulations on shark populations are poorly documented and understood.

STATE AND FEDERAL MANAGEMENT REGULATIONS

Atlantic Ocean

Federal Regulations

The development of fisheries management plans beyond state waters in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea is the responsibility of five regional fisheries management councils. In 1989, the five councils asked the Secretary of Commerce to develop a shark fisheries management plan because of concern that the lengthy schedule for the development of a five-council plan would allow further depletion of shark populations. The councils requested a plan that would cap the growth of the commercial shark fishery, establish a recreational bag limit, eliminate the practice of finning, and start data collection. In 1993, the National Marine Fisheries Service prepared the *Fisheries Management Plan for Sharks of the Atlantic Ocean* in response to this request (NOAA 1993).

Thirty-nine Atlantic species are included in the management plan: 22 species in the large coastal group, seven species in the small coastal group, and 10 species in the pelagic group (Table 3). The maximum sustained yield per annum (MSY) of each group was estimated at 3,800 mt dressed weight (large coastal), 2590 mt (small coastal), and 1560 mt (pelagic). To rebuild the stocks of large coastal species to their MSY level, the National Marine Fisheries Service recommended a reduction in landings to 2436 mt in 1993; a reduction of more than 34 percent from 1991. For pelagic species, a semi-annual quota of 290 mt was recommended, and no commercial fishing restrictions were planned for small coastal sharks because landings already seemed to be below the MSY level.

The management plan allows for annual increases in the commercial catch of large coastal and pelagic sharks. Subsequent evaluations in 1994 and 1995 revealed no strong evidence of recovery and, therefore, the National Marine Fisheries Service recommended an indefinite delay in the quota increases. The 1994 evaluation also indicated that the annual harvest limits be supplemented by closure of nurseries in directed fisheries during the pupping season. Because most of the nurseries are in coastal waters, these proposed closures would be under state jurisdictions. A closure of breeding grounds and nurseries of nurse sharks during the mating season has been implemented in the Dry Tortugas National Park (Carrier 1996; Carrier and Pratt 1996). Although such conservation measures have been taken in other countries (Williams and Schaap 1992), this closing of a mating area for the protection of a shark species was the first in the United States.

Recreational bag limits were set at 5 sharks per person for the small coastal group and 4 sharks per boat per trip for the combined large coastal and pelagic groups. The limits were expected to keep the combined recreational landings of large coastal and pelagic sharks under the total allowable catch of 1444 mt.

The management plan also prohibited the practice of finning. Fins may be sold only in proportion to the carcasses sold to a maximum of 5 percent fins per dressed carcass weight.

State Regulations

The state regulations for the shark fisheries on the Atlantic and Gulf coast waters vary somewhat from state to state, but nearly all follow the federal ban on finning. Recreational bag limits in states with national park units supporting shark fisheries are included in Table 5. Florida implemented a management plan for of sharks in April 1992 and set daily bag limits of 1 per person or 2 per boat regardless of species. Maryland and Virginia implemented daily bag limits of 1 shark per person (excluding spiny dogfishes, the harvest of which is not restricted) and prohibited longlines in tidal waters. Texas enforces a daily bag limit of 5 per person regardless of species. Georgia and Massachusetts follow federal regulations. North Carolina, New York, and the Virgin Islands had no bag limits of sharks in 1996.

Pacific Ocean

Federal Regulations

At present, federal regulations specifically for the taking of sharks in the Pacific Ocean are few. The Western Pacific Fishery Management Council published a management plan of pelagic fishes, and commercial fishing of some oceanic shark species are covered under this plan (WPFMC 1995). Area closures in the plan included a prohibition on foreign longline vessels within 241.4 km (150 miles) of the Hawaiian Islands and Guam and within 19.3 km (12 miles) of each U.S. Pacific possession, and a prohibition of the use of drift-gill nets by foreign vessels. The plan includes no prohibition of finning and no restrictions on the recreational fishery.

State Regulations

California has the most extensive recreational and commercial shark fishery on the West Coast and is aggressively regulating the fishery (Table 5; Leeanne Laughlin, personal communication). Finning and set gillnets are prohibited in state waters. Sport anglers are encouraged to participate in catch-and-release of sharks and in a tagging program for the collection of data on growth and movement of pelagic sharks. The recreational daily bag limits per person of several shark species are 3 leopard sharks, 2 blue sharks, 2 thresher sharks, 2 shortfin makos, 1 soupfin shark, 1 sixgill shark, and 1 sevengill shark. The minimum size limit for leopard shark in the recreational fishery is 91 cm (36 inches) total length. There are no size limits on other shark species in the recreational fishery. The minimum size limits of angel sharks in the commercial fishery is 106 cm (42 inches) total length for females and 101 cm (40 inche) total length for males. In addition, white sharks (Carcharodon carcharias) are protected in state waters.

The commercial shark fishery in Washington, particularly in the Puget Sound, is primarily for dogfishes. Seasons have been set for commercial fishing of dogfishes that vary by fishing area. Recreational shark fishing is covered under regulations for bottomfishes and include a daily bag limit of 2 fishes per person.

Hawaii does not have a targeted shark fishery, a ban on finning, or specific regulations of shark fishing. In recent years, the market for shark fins has increased, and shark landings have increased to about 1.9 million kilograms in 1995-96 from about 1.0 million kilograms in 1993-94 (WPRFMC 1995; Walter Ikehara, personal communication). Most sharks (mainly blue sharks) are caught incidentally in longline fisheries that target other species, and many are finned (WPRFMC 1995; Leslie Ann McGee, personal communication). Officials there have expressed concern over the issue of finning and are looking into the matter (Walter Ikehara, personal communication). Shark fishing in American Samoa and Guam is relatively rare, and no regulations target sharks (WPRFMC 1995; Phil Langford, personal communication).

The Pacific States Marine Fisheries Commission published a fishery management plan for the thresher shark off the coasts of California, Oregon, and Washington (Stick et al.1990). The commission set the guideline for a coastwide annual harvest of thresher sharks at 41,337 kg

dressed weight and recommended that the catch of juvenile sharks be discouraged.

NATIONAL PARK SERVICE - FISHERIES POLICY AND REGULATION

The National Park Service administers a system of 369 park units scattered across the continental United States, Alaska, Hawaii, the Virgin Islands, and the Western Pacific. The 32 million hectares in this system represent about 12 percent of the total federal landholdings (Keystone Center 1991). Forty-four units or 12 percent of all parks along the Atlantic, Gulf, and Pacific coasts provide marine and coastal habitats that support coastal and nearshore shark populations. Many of these parks represent some of the finest examples of marine ecosystems in the world, providing relatively undisturbed habitats that support a diversity of fish and marine invertebrate populations. In fact, the National Park Service marine units represent a disproportionately large percentage of the world's designated Biosphere Reserves and World Heritage Sites (Eichbaum et al. 1996).

General Authorities and Limitations

Fisheries management in the National Park System is directed by policy and guidelines with roots in the founding legislation of the National Park Service, the National Park Service Organic Act of 1916 (16 U.S.C. 1 et seq.[1988], Aug. 25, 1916, ch. 408, 39 Stat. 535). The act directs the Secretary of the Interior and the National Park Service to manage national parks and monuments to "conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (Shelton and Fox 1994, page 6). These general powers were broadened by the Redwood National Park Act (16 U.S.C. 79a-79q [1988], 82 Stat. 931, Pub. L. 90-545) in which the Congress gave further direction to the secretary to ensure that the management and administration of the national park system "shall not be exercised in derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided by Congress" (Shelton and Fox 1994, page 10). Consistent with these broad authorities, the current fisheries management policies of the National Park Service emphasize the restoration and preservation of natural assemblages of native species (Panek 1994). According to the general regulations (36 CFR 1.4) of the National Park Service, the term *fish* and, hence, *fisheries management*, include any member of the subclasses Agnatha (lampreys and hagfishes), Chondrichthyes (sharks and rays) and Osteichthyes (bony fishes) and includes all molluscs or crustaceans in saltwater. The National Park Service manages all park resources with an emphasis on fundamental ecological processes, species, and communities (National Park Service 1988). Fisheries management is designed to preserve or restore the natural behavior, genetic variability and diversity, and ecological integrity of fish populations. Management of resources and users in parks with migratory or anadromous species must include provisions for the preservation of these animals and their habitats inside park boundaries and for the cooperation with other management authorities to ensure the preservation of their populations and habitats outside the parks.

Recreational Fishing

Current policies of the National Park Service allow recreational fishing in parks where it is authorized by federal law or where it is not specifically prohibited and does not interfere with the functions of natural aquatic ecosystems or riparian zones (National Park Service 1988). In addition, these policies stipulate that any restrictions on recreational uses are limited to the minimum necessary to protect park resources and to promote the safety and enjoyment of visitors. However, recreational fishing may be restricted by the service--after consultation with the states--at any time to achieve the objectives of park-resource management, to administer public safety and administration, or to accommodate public use and enjoyment. This policy also directs managers not to allow harvests that reduce the reproductive potential of a population or radically alter its natural age structure.

The National Park Service Organic Act also grants the Secretary of the Interior the authority to implement rules and regulations as deemed necessary or proper for the use and management of the parks, monuments, and reservations under the jurisdiction of the National Park Service (National Park Service 1991). Areas inside park boundaries may be zoned to protect nurseries or breeding grounds from fishing, boating, swimming, or other uses by visitors. Fishing tournaments and other competitive recreational fishing are generally not compatible with the goals and objectives of resource management by the National Park Service. Such events may be permitted only if the activity is clearly authorized and will not result in any derogation of the values and purposes for which the park was established.

Fishing regulations in 36 CFR Part 2.3 apply on lands and waters that are inside park boundaries and under the legislative jurisdiction of the United States regardless of ownership. In addition, in parks where the National Park Service has concurrent or proprietary jurisdiction, state laws and regulations also apply to the fishery. However, the National Park Service retains the authority to implement more restrictive regulations.

Commercial Fishing

Commercial fishing is allowed only where specifically authorized by federal law or treaty rights (National Park Service 1988). Marine parks with authorized commercial fishing include Assateague Island National Seashore, Biscayne National Park, and Canaveral National Seashore (Appendix). When commercial fishing is authorized, the National Park Service must balance the allocation of the fishery resource with the needs of the marine ecosystem and must continue to provide the maintenance of self-sustaining fish populations and minimize the adverse effects on other marine resources. The National Park Service manages most commercial fishing by permits and imposes a reporting system on harvest inside park boundaries. In 1995, no National Park Service unit reported commercial harvest of sharks.

Interagency Coordination

Because of the complexity of the regulatory framework, cooperation and collaboration with state and local governments are critical to the long-term sustainability of marine resources in parks. Differences in regulations of minimum sizes of fishes taken by anglers, angling seasons, creel limits, and the manner of taking should be documented and assessed, and the managing agencies should seek consistency of regulations. Specifically, the regulations of sportfishing and recreational use must be evaluated periodically for not only interjurisdictional consistency but for assessment of their effectiveness in resource management. Such assessments must correlate with the monitoring of fish populations and with creel census data. Regulations may permit reasonable use and enjoyment of the resource but should not compromise the productivity and sustainability of the fisheries or their resource bases. The objectives of fishery management should be biological balance and integrity as well as the quality of the fishing experience.

SHARK MANAGEMENT IN NATIONAL PARK UNITS WITH MARINE RESOURCES

Coastal and other parks (Appendix) follow state or territorial fishing regulations. Targeted commercial shark fishing is either rare or does not exist in many coastal parks including parks in American Samoa, Hawaii, Maine, North Carolina, the Virgin Islands, and Washington. A recreational fishery for salmon sharks (Lamna ditropis) is developing in the Kenai Fjords National Park, Alaska, but targeted shark fishing in other parks in Alaska seems to be rare. Commercial fishing for angel sharks was substantial in the Channel Island National Park in California until 1992 when gillnets were banned from state waters. Since then, the fishery has virtually disappeared (Dan Richards, personal communication). Other parks are faced with the problem of jurisdiction to only the low tide line; such parks have control over shore-based fishing and boats that dock on park property but cannot regulate other boats and the placement of gillnets in waters adjacent to the park. Some of these parks are the Timucuan Ecological and Historic Preserve in Florida, the Cape Hattaras National Seashore in North Carolina, and the Cumberland Islands National Seashore in Georgia.

In parks, recreational shark fishing is far more common than commercial fishing. Although the main cause of the decline of many shark populations has been overfishing by the commercial vessels, recreational fishing has been implicated in the decline of dusky sharks (Musick et al. 1993) and could adversely affect other populations because mainly juvenile sharks are taken in recreational fisheries. However, evidence from creel surveys at Everglades National Park suggest that the catch and harvest of sharks represents less than one percent of the total recreational catch (Thomas Schmidt, personal communication).

Half or more of the recreational harvest of sharks is from boats (Hoff and Musick 1990). In most parks, shark fishing from boats would occur outside of park waters, and the park would control the catch of only boats that return to park property. In the Everglades National Park in Florida, shark fishing is done mainly from boats. The daily bag limit is 2 per boat and release is required of sharks that cannot be kept. Recreational fishing in the Channel Island National Park seems to

be primarily for leopard sharks and makos from boats (Dan Richards, personal communication).

Fishing for sharks from shore is popular in some parks. A surf fishery at Padre Island National Seashore in Texas targets sharks. Anglers land many species including sand tigers and bull, blacktip, nurse, sandbar, and spinner sharks (Darrell Echols, personal communication). The bag limit for sharks in Texas is 5 per person per day, but how many sharks are landed yearly on the Padre Island National Seashore and whether this fishery is adversely affecting local populations are not known. In several other parks, sharks are landed by fishing in the surf or from piers. These parks include Assateague Island National Seashore in Maryland and Virginia, Fire Island National Seashore in New York, Cape Hatteras National Seashore in North Carolina, Cape Cod National Seashore in Massachusetts, and Gateway National Recreation Area in New Jersey and New York. From most parks, data on the annual landing of sharks are not available.

Shark nurseries have been documented in several parks in the Atlantic Ocean and Gulf of Mexico. Nurseries for blacktip, lemon, nurse, bonnethead, and bull sharks are in Everglades National Park, and nurseries for lemon sharks have been identified in Biscayne Bay (Thomas Schmidt, personal communication). Nurseries for sandbar and dusky sharks occur in Assateague Island National Seashore (John Musick, personal communication), nurseries for blacktip sharks are known at Cumberland Island National Seashore, and nurseries for nurse sharks and small reef sharks (probably blacktip sharks) have been documented in Virgin Islands National Park (Virginia Garrison, personal communication). Many other nurseries that have not yet been delineated may exist in parks along the Atlantic and Gulf coasts. The identification of nurseries in the Pacific Ocean is still in its early stages. Whether shark nurseries occur in parks on the Pacific Ocean is not yet known.

The protection of shark nursery areas is considered a critical factor in shark conservation (NOAA 1994; Oliver 1996). Recreational fisheries take many juvenile sharks that could affect populations by limiting recruitment to spawning age adults. Other human activities and environmental degradation that may drive juvenile sharks or females about to give birth away from the nurseries and into areas with more predators could affect survival and reproductive success. Environmental degradation of nursery habitat has been implicated in the decline of several shark species such as the smooth hammerhead (Sphyrna zygaena) in the Mediterranean Sea and the lemon shark in Florida (Oliver 1996). Closure of shark nurseries to directed fishing during the pupping season has been suggested to increase the probability of recovery (NOAA 1994).

MANAGEMENT OPTIONS

The following management options are offered for consideration by the superintendents and resource managers of the National Park Service. The composition of shark populations, fishing pressure, presence or absence of nurseries, and condition of habitat differ greatly among parks, and the needs of each park, therefore, also differ. The selection of appropriate management requires scientific knowledge of the status of populations or stocks inside and outside of park boundaries and information about known risks and threats to the species. Management decisions

should include an assessment of potential benefits from the proposed action for the targeted species and an assessment of the potential effects on the recreational or commercial fisheries.

The implementation of some management options may require knowledge and expertise beyond those that may normally be expected of park managers. Establishing and maintaining partnerships with research and management cooperators are important for shark management. Park managers should consider developing memoranda of understanding or cooperative agreements with local universities and state agencies. Parks with complex fisheries management issues involving highly migratory species such as sharks should consider the development of a Fishery Management Plan. Such plans provide park managers with provisions for addressing management goals, strategies, and priorities for the long-term protection and management of fishes in their parks.

Closure of Nurseries to Fishing or Boating

Nurseries could be closed to all activities or to targeted fishing during pupping seasons. The closure of nurseries to directed fishing during the pupping season was suggested by the National Marine Fisheries Service (1994) as an important measure for shark conservation. In Dry Tortugas National Park, nurseries were closed during breeding and pupping seasons to protect the local population of nurse sharks (Carrier and Pratt 1996).

Before closing areas, the nurseries and pupping seasons of the species of concern must be identified. In addition, the levels of human activities that probably disturb or displace juveniles and gravid females must also be considered. Given the increased interest in shark conservation in recent years, more scientists may be willing to work with park-resource managers to answer these questions.

Closure of Mating Areas

A few mating areas of the nurse shark, which mates in shallow waters, have been identified. After it was observed that the presence of divers or boats disrupted mating, one such area in the Dry Tortugas National Park was closed during the mating season, which occurs from May through August (Carrier 1996; Carrier and Pratt 1996). The effectiveness of this regulatory closure for the local population of nurse sharks is yet to be determined. Other species thought to mate in shallow waters in parks in southern Florida include the lemon, bonnethead, and bull sharks. Mating areas of these species have not been defined.

Most other species of sharks are thought to mate in deeper waters (beyond most park waters), making observation and identification of mating areas far more difficult. More mating areas probably will be identified in the future. Closure of mating areas that are under park jurisdiction during mating seasons may benefit the shark populations. However, data to support this management option are not yet available, and additional research and field observations will be required to assess its effectiveness.

Protection of Habitat in Nurseries

Habitat degradation has been implicated in the decline of several shark populations (Oliver 1996) and, in some parks, may be of greater concern than recreational fishing pressure (Thomas Schmidt, personal communication). Numerous forms of environmental degradation may affect shark populations. Coastal wetlands, bays, mangroves, coral reefs, kelp forests, and seagrass beds are susceptible to alteration of freshwater inflows and general water quality degradation (NOAA 1993; Oliver 1996). Future investigations of the effects of habitat degradation on juvenile sharks and shark reproduction are important (Pratt and Otake 1990). The development of protocols for monitoring of marine resources should be given high priority in the National Park Service resource management planning process. Identification and management of habitat and water quality impairments will be critical components for any management of shark populations and fisheries in coastal park units.

Prohibition or Restriction of Shark Fishing in Park Waters and From Shore and Piers

Half or more of the recreational harvest of sharks is from boats off shore (Hoff and Musick 1990; Karpov et al. 1995), which in most cases is outside waters and jurisdictions of parks. Whereas in the past, anglers killed rather than released many sharks (Hoff and Musick 1990), this practice is far less common now. Many states stipulate bag limits and encourage the catch-and-release of sharks. Some states conduct tag-and-release programs in which anglers participate and thereby contribute to the body of information on sharks.

In the early 1980s, the dusky shark population began to decline before the rapid increase in commercial fishing in the mid 1980s (Musick et al. 1993). This decline was seemingly due to recreational fishing pressure. Currently, the recreational shark fishery takes far fewer sharks than the commercial fisheries but takes relatively more juvenile sharks (John Musick, personal communication). The possible adverse effect of this on recruitment into the breeding populations of most sharks is not known and could vary considerably by stock status and fishing intensity (Gulland 1993). Additional research is needed to determine whether closure of shark fisheries in parks could measurably improve the recovery of depressed populations. Whether restrictive bag limits or catch-and-release regulations are effective in management of sharks is also not known.

Prohibition of Finning in Pacific Parks

The practice of finning--removal of fins and discarding of the carcass--is prohibited in the Atlantic Ocean and in California waters. Finning in the Pacific Ocean, in United States territories, and in states on the Pacific Ocean other than California is however not banned. Most finning in the Pacific Ocean is by commercial fishers and mainly of blue sharks that are incidentally caught in longline fisheries (Leslie Ann McGee, personal communication) and, therefore, is probably not done in park waters. A ban on the possession of shark fins without the carcass inside the boundaries of National Park Service units may be an appropriate first step to reduce this wastefulness. Although such a measure would be consistent with the management policies of the National Park Service, resource managers must recognize that it alone would probably have little

or no effect on the overall shark populations. The National Park Service has jurisdiction over only a small portion of shark-inhabited waters in the Pacific Ocean.

Prohibition of Gillnets in Park Waters

The use of gillnets causes nearly 100 percent mortality of sharks (Bonfil 1994) and is prohibited in the shallow waters of some states such as California and Florida. In the Everglades National Park, a request for sampling with gillnets was turned down because of concerns for high mortality of sharks and other finfishes (Thomas Schmidt, personal communication). In some states, gillnets are not prohibited, and the use of them has been observed in park waters of the Fire Island National Seashore in New York (Jay Lippert, personal communication). In shark-inhabited waters of parks where commercial fishing is authorized, the incidental catch of sharks should be assessed to determine whether shark populations are affected. If the incidental catch is substantial, the elimination of this gear may be necessary to protect depressed populations.

Increased Enforcement of Federal and State Regulations

The management of any fishery requires not only scientifically based regulations and assessments but enforcement. The multi-jurisdictional nature of fisheries regulations in the marine waters of the National Park System necessitates interagency coordination and cooperation. In many marine parks in which the National Park Service has limited proprietary jurisdiction or controls public use only to the low tide line, the enforcement of either the National Park Service regulations or state fishing regulations requires cooperative relations with state and local enforcement authorities. In parks with extensive marine waters, joint patrols and enforcement improve law enforcement effectiveness and increase the benefits of fishery regulations to park fisheries, including sharks. Enforcement of prohibitions on the possession of shark fins in park waters, in park marinas, on boat ramps, or in fisheries on beaches or piers along the Atlantic and Gulf coasts should be given priority by superintendents of marine fisheries enforcement.

In addition, as pointed out by Bohnsack and Ault (1996), traditional management frequently fails to adequately protect fish populations because of mortalities from hooking, inabilities of authorities to control fishing, poor compliance of fishers with regulations, and unenforced or unenforceable regulations. Superintendents should communicate with federal, state, and local authorities to ensure that all fishing regulations are appropriate and enforceable in park units.

RESEARCH NEEDS

Needed research and management of marine resources in the national parks were recently reviewed by Panek (1995), and the values of marine refugia and managed areas were reviewed by Eichbaum et al. (1996). Information about marine resources in national parks is limited, and information about sharks and fisheries is even more limited. Implementation of many management options recommended in this report require information about populations and habitats.

In many parks, the composition of shark populations, presence or absence of nursery areas, number and composition of annual shark landings, and quality of shark habitat are unknown. The assessment of shark abundance inside the boundaries of some parks could be accomplished by creel surveys. In some parks, these data may already be available from surveys by the state, the National Marine Fisheries Service, or the National Park Service

Criteria for the delineation of nurseries were proposed by Castro (1993a) and have been used in certain areas of the southeastern United States. The identification of nurseries inside park boundaries is necessary for the conservation of sharks. Cooperation with state and university shark biologists may enable park managers to identify nursery areas and pupping seasons for species in park waters.

The quality of shark habitat, especially nursery habitat, is thought to play an important role in shark abundance and recruitment. But information about the habitat requirements of many shark species is scarce (Oliver 1996). Park-resource managers could begin to address this problem by determining the the presence, species, abundance, population structure, and distribution of sharks in their waters while monitoring factors such as temperature, salinity, siltation, contaminants, change in abundance of prey species, and loss of submerged aquatic vegetation. All may require further research before park managers can implement appropriate and effective management. Specific research needs should be addressed in Resource Management Plan Project Statements of parks.

PUBLIC EDUCATION

Despite the efforts of several conservation organizations, the public's view of sharks is usually negative. Sharks are feared and not recognized as a valuable natural resource. The National Marine Fisheries Service (NOAA 1993) identified limited public education about the value of sharks in the marine ecosystem as one of the problems associated with the excessive exploitation of sharks. The report suggested that increased education of the public would contribute to shark conservation. Interpretive programs that emphasize the role of sharks in the ecosystem may help to reverse the unfavorable image of sharks.

Interpretation and education programs in the National Park System are well established and generally considered to be important for resource preservation and management. Information on marine conservation, fisheries management, and the importance of sharks and other fishes to the integrity and health of marine ecosystems should be an important message by interpretive programs in marine parks.

In addition to reaching the average park visitor, interpretive programs must target recreational anglers, particularly those fishing for sharks. Anglers have a major responsibility for advocating shark conservation. Excessive exploitation in recreational shark fisheries has been implicated in the population declines of several species. Park-sponsored fishing clinics, National Fishing Week events, and other recreational fishing programs in marine parks must recognize shark conservation, angler ethics, and species conservation as important interpretive themes.

LITERATURE CITED

Anderson, E.D., and K. Teshima. 1990. Workshop on fisheries management. Pages 499-503 *in* H. L. Pratt, S.H. Gruber, and T. Taniuchi, editors. Elasmobranchs as living resources: advances in the biology, ecology, systematics, and the status of fisheries. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Technical Report NMFS 90.

Bohnsack, J.A., and J.S. Ault. 1996. Management strategies to conserve marine biodiversity. Oceanography 9(1): 73-82.

Bonfil, R. 1994. Overview of world elasmobranch fisheries. Food and Agricultural Organization. Fisheries Technical Paper No. 341. 119 pp.

Bonfil, R., R. Mena, and D. de Anda. 1993. Biological parameters of commercially exploited silky sharks, Carcharhinus falciformis, from the Campeche bank, Mexico. Pages 73-84 *in* S. Branstetter, editor. Conservation Biology of Elasmobranchs. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Report NMFS 115.

Branstetter, S. 1990. Early life-history implications of selected Carcharhinoid and Lamnoid sharks of the northwest Atlantic. Pages 17-28 *in* H. L. Pratt, S.H. Gruber, and T. Taniuchi, editors. Elasmobranchs as living resources: advances in the biology, ecology, systematics, and the status of fisheries. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Technical Report NMFS 90.

Baillie, J., and B. Groombridge. 1996. 1996 IUCN red list of threatened animals. International Union for Conservation of Nature and Natural Resources, Gland, Switzerland. 368 pp.

Branstetter, S., and J.A. Musick. 1994. Age and growth estimates for the sand tiger in the northwestern Atlantic Ocean. Transactions of the American Fisheries Society 123: 242-254.

Cailliet, G.M., D.B. Holts, and D. Bedford. 1993. Review of the commercial fisheries for sharks on the west coast of the United States. Pages 13-29 *in* J. Pepperell, J. West and P. Woon, editors. Shark conservation: proceedings of an International workshop on the conservation of elasmobranchs held at Taronga Zoo, Sydney, Australia, 24, February 1991.

Carrier, J.C. 1996. Identification and closure of nurse shark breeding grounds. Shark News 6:9.

Carrier, J.C., and H.L. Pratt. 1996. Habitat management and closure of a nurse shark breeding and nursery ground. Journal of Fisheries Research. in press.

Castro, J. I. 1983. The sharks of North American Waters. Texas A&M University Press, College Station, Texas. 180 pp.

Castro, J. I. 1993a. The shark nursery of Bulls Bay, South Carolina, with a review of the shark nursery areas of the southeastern coast of the United States. Environmental Biology of Fishes 38: 37-48.

Castro, J. I. 1993b. A field guide to the sharks commonly caught in commercial fisheries of the southeastern United States. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Memorandum NMFS-SEFSC-338, 47 pp.

Casey, J.G., F.J. Mather, J.M. Mason, and J. Hoenig. 1978. Offshore fisheries of the middle Atlantic bight. Pages 107-129 *in* H. Clepper, editor. Proceedings of the Second Annual Marine Recreational Fisheries Symposium. Sport Fishing Institute, Marine recreational fisheries. Washington, D.C. 176 pp.

Eichbaum, W.M., M.P. Crosby, N.T. Agardy, and S.A. Laskin. 1996. The role of marine and coastal protected areas in the conservation and sustainable use of biological diversity. Oceanography 9(1): 60-70.

Gulland, J.A. 1983. Fish stock assessment: A manual of basic methods. John Wiley and Sons, New York., 223 pp.

Hoff, T.B., and J.A. Musick. 1990. Western North Atlantic shark-fishery management problems and informational requirements. Pages 455-472 *in* H. L. Pratt, S.H. Gruber, and T. Taniuchi, editors. Elasmobranchs as living resources: advances in the biology, ecology, systematics, and the status of fisheries. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Technical Report NMFS 90.

Holts, D.B. 1988. Review of U.S. west coast commercial shark fisheries. Marine Fisheries Review, 50(1): 1-8.

Karpov, K.A., D.P. Albin, and W.H. Van Buskirk. 1995. The marine recreational fishery in northern and central California. California Department of Fish and Game, Fish Bulletin 176. 192 pp.

Keystone Center. 1991. Final consensus report on the Keystone Policy Dialogue on Biological diversity on federal lands. The Keystone Center, Keystone, Colorado. 96 pp.

Musick, J.A. 1995. Critically endangered large coastal sharks, a case study: the sandbar shark, Carcharhinus plumbeus. Shark News 5: 6-7.

Musick, J.A., S. Branstetter, and J.A. Colvocoresses. 1993. Trends in shark abundance from 1974 to 1991 for the Chesapeake Bight region of the U.S. mid-Atlantic coast. Pages 1-18 *in* S. Branstetter, editor. Conservation Biology of Elasmobranchs. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Technical report NMFS 115.

Myers, R.A. and N.J. Barrowman. 1996. Is fish recruitment related to spawner abundance? Fishery Bulletin 94(4): 707-723.

NOAA (National Oceanic and Atmospheric Administration). 1993. Fishery management plan for sharks of the Atlantic Ocean. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, U.S. Department of Commerce. 167 pages and appendixes.

NOAA (National Oceanic and Atmospheric Administration). 1994. Report of the shark evaluation workshop, March 14-18, 1994. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, U.S. Department of Commerce. 47 pp.

NOAA (National Oceanic and Atmospheric Administration). 1995. 1995 Shark evaluation annual report. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, U.S. Department of Commerce. 23 pp.

National Park Service. 1988. Management Policies. U.S. Department of the Interior, National Park Service, Washington, D.C. No pagination.

National Park Service. 1991. NPS-77, Natural Resource Management Guideline. U. S. Department of the Interior, National Park Service, Washington, D. C. No pagination.

National Park Service. 1992. A Heritage of fishing: the National Park Service recreational fisheries program. U.S. Department of the Interior, National Park Service, Washington, D.C. 20 pp.

Oliver, A.L. 1996. An overview of the biological status of shark species. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, U.S. Department of Commerce. Draft.

Panek, F.M. 1994. Recreational fishing in the National Parks: Why is there a question? Fisheries 19(19):6-7.

Panek, F.M. 1995. Preservation and management of marine and coastal fisheries in the National Park System: A review of research programs. Natural Areas Journal 15(1):7-11.

Parrack, M.L. 1992. Report of the Atlantic coastal shark fishery analysis review, September 30, 1992. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Miami, Florida. (As cited in National Oceanic and Atmospheric Administration 1993).

Pratt, H.L. and T. Otake. 1990. Recommendations for work needed to increase our knowledge of reproduction relative to fishery management. Pages 509-510 *in* H. L. Pratt, S.H. Gruber, and T. Taniuchi, editors. Elasmobranchs as living resources: advances in the biology, ecology, systematics, and the status of fisheries. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Technical Report NMFS 90.

Schmidt, T.W. 1986. Food of juvenile lemon sharks, Negaprion brevirostris (Poey), near Sandy Key, western Florida Bay. Florida Scientist 49(1):7-10.

Shelton, N., and L. Fox. 1994. An introduction to selected laws important for resources management in the National Park Service. Natural Resource Report NPS/NRPO/NRR-94/15. 48 pp.

Smith, S.E. 1992. Fish resources: Leopard shark. Pages 48-49 *in* W.S. Leet, C.M. Dewees, and C.W. Haugen, editors. California's living marine resources and their utilization. Sea Grant Extension Publication, UCSGEP-92-12.

Springer, S. 1951. The effects of fluctuations in availability of sharks on a shark fishery. Pages 140-145 *in* Proceedings of the Gulf and Caribbean Fisheries Institute, 4th Annual Session. Coral Gables, Florida (as cited in National Oceanic and Atmospheric Administration 1993).

Springer, S. 1967. Social organization of shark populations. Pages 149-174 *in* P.W. Gilbert, R.F. Matheson, and D.P. Rall, editors. Sharks, skates, and rays. John Hopkins Press, Baltimore, Maryland.

Stick, K., G. Fleming, A. Millikan, L. Hreha, and D. Hanson. 1990. Interjurisdictional fishery management plan for thresher shark off the coasts of California, Oregon, and Washington. Pacific States Marine Fisheries Commission, Portland, Oregon. 28 pp.

Wetherbee, B.M., S.H. Gruber, and E. Cortes. 1990. Diet, feeding habits, and consumption in sharks, with special reference to the lemon shark, Negaprion brevirostris. Pages 29-84 *in* H.L. Pratt, S.H. Gruber, and T. Taniuchi, editors. Elasmobranchs as living resources: advances in the biology, ecology, systematics, and the status of fisheries. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Report NMFS 90.

Williams, H., and Schaap, A.H. 1992. Preliminary results of a study into the incidental mortality of sharks in gillnets in two Tasmanian shark nurseries. Australian Journal of Marine and Freshwater Resources 43: 237-50 (as cited in Oliver 1996).

(WPFMC) Western Pacific Regional Fishery Management Council. 1995. Pelagic fisheries of the Western Pacific region, 1994 Annual report. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii.

Wright, V.D. 1981. Some observations on the biology of the sharks of the Florida Keys and Adjacent waters. Masters Thesis. Florida Atlantic University, Boca Raton. 477 pp. (as cited in Castro 1993a).

PERSONAL COMMUNICATIONS

Echols, D. 1996. Resource Management Specialist. National Park Service, Padre Island National Seashore, Padre Island, Texas.

Garrison, V. 1996. Resource Management Specialist. National Park Service, Virgin Islands National Park, Virgin Islands.

Holts, D.B. 1996. Fishery Biologist. Southwest Fisheries Science Center, National Marine Fisheries Service, La Jolla, California.

Ikehara, W. 1996. Aquatic Biologist, Hawaii Department of of Land and Natural Resources, Division of Aquatic Resources, Honolulu, Hawaii.

Langford, P. 1996. Acting Director of Marine and Wildlife Resources, American Samoa.

Laughlin, L. 1996. Marine Biologist, Marine Resources Division, California Department of Fish and Game, Long Beach, California.

Lippert, J. 1996. Chief Ranger. National Park Service, Fire Island National Park, New York.

McGee, L.A. 1996. Marine Biologist, NMFS, Southwest Region, Long Beach, California.

Musick, J.A. 1996. Professor. Virginia Institute of Marine Science. Gloucester Point, Virginia.

Richards, D. Marine Biologist. National Park Service, Channel Islands National Park, California.

Schmidt, T. 1996. Marine Fishery Biologist. National Park Service, Everglades National Park, Florida.

Table 1. Recreational and commercial shark landings in the Atlantic Ocean (mt = metric ton; National Oceanic and Atmospheric Administration 1993).

Year	Recreational landings (mt)	Commercial landings (mt)
1979	11512	135
1980	3210	458
1981	9431	666
1982	2599	590
1983	5527	724
1984	1975	846
1985	5305	969
1986	4243	1618
1987	4175	3603
1988	2728	5276
1989	1666	7122

Table 2. Age and length at maturity of selected shark species. Length is given in total length. (from Branstetter and Musick 1994; Bonfil et al. 1993; Musick 1995; Castro 1983; Branstetter 1990; Holts 1988)

Common name Large coastal group	Scientific name	Males (age and length at maturity)	Females (age and length at maturity)
Sand tiger	Odontaspis taurus	4-5 year (190-195 cm)	6 year (220 cm)
Silky shark	Carcharhinus falciformis	10 year (225 cm)	>12 year (232-246 cm)
Sandbar shark	Carcharhinus plumbeus	13-16 year (183 cm)	13-16 year (179-183 cm)

Common name Small coastal group	Scientific name	Males (age and length at maturity)	Females (age and length at maturity)
Atlantic sharpnose shark	Rhizoprionodon terraenovae	3 year (83 cm)	4 year (83 cm)
Bonnethead	Sphyearna tiburo	2 year (75 cm)	2 year (75 cm)

Common name Pelagic group	Scientific name	Males (age and length at maturity)	Females (age and length at maturity)
Thresher shark	Alopias spp.	5 year (333 cm)	7 year (390 cm)
Soupfin shark	Galeorhinus zyopterus	8 year (120-170 cm)	11 year (130-185)
Blue shark	Prionace glauca	4-5 year (220 cm)	5-6 year (220 cm)

Table 3. Sharks commonly caught in the Atlantic Ocean and Gulf of Mexico. This list includes all species in the fisheries management unit of the management plan proposed by the National Marine Fisheries Service (NOAA 1993). It includes also a few species commonly caught in recreational fisheries that are in the plan only for data collection. Information on common commercially harvested species was taken from Castro (1993b) and recreationally harvested species were taken from Hoff and Musick (1990) and the National Marine Fisheries Service (1993).

Common name Large coastal sharks	Scientific name	Recreational	Commercial
Nurse	Ginglymostoma cirratum	+	+
Whale	Rhincodon noronhai		
Bigeye sand tiger	Odontaspis taurus		
Sand tiger	O. tauruspinna	+	+
Basking	Cetorhinus maximus		+
White	Carcharodon carcharias	+	+
Bignose	Charcharhinus altimus		+
Narrowtooth	C. brachyurus		
Spinner	C. brevipinnais	+	+
Silky	C. falciformis		+
Galapagos	C. galapagensis		+
Bull	C. leucas	+	+
Blacktip	C. limbatus	+	+
Dusky	C. obscurus	+	+
Caribbean reef	C. perezi		
Sandbar	C. plumbeus	+	+
Night	C. signatus		+
Tiger	Galeocerdo cuvieri	+	+
Lemon	Negaprion brevirostris	+	+
Scalloped hammerhead	Sphyrna lewini	+	+
Great hammerhead	S. mokarran	+	+
Smooth hammerhead	S. zygaena	+	+

Table 3. (continued)

Common name Small coastal sharks	Scientific name	Recreational	Commercial
Blacknose	Carcharhinus acronotus		+
Finetooth	C. isodon		+
Smalltail	C. porosus		
Caribbean sharpnose	Rhizoprionodon porosus		
Atlantic sharpnose	R. terraenovae	+	+
Bonnethead	Sphyrna tiburo	+	+
Atlantic angel	Squatina dumerili		+

Common name Pelagic sharks	Scientific name	Recreational	Commercial
Sixgill	Hexanchus griseus		+
Bigeye sixgill	H. vitulus		+
Sharpnose sevengill	Heptranchias perlo		+
Bigeye thrasher	Alopias superciliousus		+
Thresher	A. vulpinus		+
Shortfin mako	Isurus oxyrinchus	+	+
Longfin mako	I. paucus		+
Porbeagle	Lamna nasus		+
Oceanic whitetip	Carcharhinus longimanus		+
Blue	Prionace glauca	+	+

Common name Sharks not in management unit	Scientific name	Recreational	Commercial
Smooth dogfish	Mustelus canis	+	
Spiny dogfish	Squalus acanthias	+	+

Table 4. Sharks commonly caught in the Pacific Ocean. Information on commercially harvested species was taken from several sources (Holts 1988; Smith 1992; Holts, personal communication) and recreationally harvested species were taken from Karpov et al. (1995).

Common name Coastal group	Scientific name	Recreational	Commercial
Horn	Heterodontus francisci	+	
Silky	Carcharhinus falciformis		+
Bull	C. leucas		+
Blacktip	C. limbatus		+
Dusky	C. obscurus		+
Soupfin	Galeorhinus zyopterus	+	+
Tiger	Galeocerdo cuvier		+
Gray smoothhound	Mustelus californicus	+	
Brown smoothhound	M. henlei	+	
Pacific sharpnose	Rhizoprionodon longurio		+
Leopard	Triakis semifasciata	+	+
Hammerhead sharks	Sphyrna spp.		+
Spiny dogfish	Squalus acanthias	+	+
Pacific angel	Squatina californica	+	+

Common name Pelagic group	Scientific name	Recreational	Commercial
Sixgill	Hexanchus griseus	+	
Sevengill	Heptranchias perlo	+	
Bigeye tresher	Alopias superciliousus	+	+
Thresher	A. vulpinus	+	+
Shortfin mako	Isurus oxyrhinchus	+	+
Blue	Prionace glauca	+	common by-catch

Table 5. State regulations on recreational shark fishing. ("All" refers to all sharks in the National Marine Fisheries Service fisheries management unit listed in the Appendix. Most states also have gear restrictions or restrictions on sale of fishes that apply to recreational fishing for all finfishes.)

Atlantic and Gulf of Mexico

State	Shark species	Size limit	Daily bag limit	Seasonal closure	Protected species	Other
Florida	All	None	1 per person 2 per vessel	None	basking, whale sharks	Finning prohibited
Georgia uses federal regulations	All except dogfish sharks	None	Large coastal 4 per vessel Small coastal 5 per person	None	None	Finning prohibited
Maine	No recreational regulations					No ban on finning
Maryland	All except dogfish sharks	None	1	None	None	Finning prohibited; longlines prohibited in tidal waters
Massachusetts uses federal regulations	All except dogfish sharks	None	Large coastal 4 per vessel Small coastal 5 per person	None	None	Finning prohibited
Mississippi	All	None	Large coastal 4 per vessel Small coastal 5 per person	None	None	Finning prohibited
New York	No recreational regulations					Finning prohibited
North Carolina	All except dogfish sharks	None	None	None	None	Finning prohibited
South Carolina	All except dogfish sharks	None	Large coastal 4 per vessel Small coastal 5 per person	None	None	Finning prohibited

Table 5. (continued)

State	Shark spp.	Size limit	Daily bag limit	Seasonal closure	Protected species	Other
Texas	All species and hybrids	None	5	None	None	Finning prohibited
Virginia	All except dogfish sharks	None	1	None	None	Finning prohibited; longlines prohibited in tidal waters
U.S. Virgin Islands	No recreational regulations					
Federal waters	All	None	Large coastal 4 per vessel Small coastal 5 per person	None	None	Finning prohibited; live release over bag limit; sale of sharks prohibited

Pacific Ocean

State	Shark spp.	Size limit	Daily bag limit (per person)	Seasons	Protected species	Other
Alaska	No recreational regulations					
American Samoa	No recreational regulations					
California	leopard blue thresher shortfin mako soupfin sixgill seven gill	36 in None None None None None None	20 finfishes 3 2 2 2 1 1 1		white shark	Finning prohibited
Guam	No recreational regulations					
Hawaii	No recreational regulations					
Washington	All	None	2	None	None	None
Federal waters	No recreational regulations					

Appendix

Listing of park units with marine resources

Estimates of coastal lengths and coastal areas are based on a 1994 recreational fisheries survey by the National Park Service.

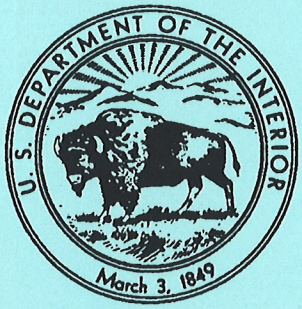
(P = proprietary; E = exclusive; C = concurrent; Miles = coastal miles; Acres = coastal acres; N/A = information not available; Shark fishing = parks that report targeted shark fishing in or adjacent to park waters; Nursery = parks that have known shark nurseries.)

Atlantic and Gulf Coastal Park Units

Park	State	Jurisdiction	Commercial fishing authorized	Miles	Acres	Shark fishing	Nursery
Acadia National Park	ME	C		52.0	390		
Assateague Island National Seashore	MD	C	+	86.0	24500	+	+
Biscayne National Park	FL	C	+	N/A	N/A	+	+
Buck Island Reef National Monument	VI	C		3.2	704		+
Canaveral National Seashore	FL	C	+	24.0	38235	+	
Cape Cod National Seashore	MA	C		50.0	12000	+	
Cape Hatteras National Seashore	NC	C	+	63.0	90	+	
Cape Lookout National Seashore	NC	C	+	56.0	N/A	+	
Colonial National Historic Park	VA	P, C,E		34.0	N/A		
Cumberland Island National Seashore	GA	C		30.0	N/A	+	+
Dry Tortugas National Park	FL	C		N/A	64000	+	+
Everglades National Park	FL	C		100.0	800000	+	+
Fire Island National Seashore	NY	N/A		52.0	7500	+	
Fort Pulaski National Monument	GA	P		31.0	5365	+	
Fort Raleigh National Historic Site	NC	C		0.7	N/A		
Fort Sumter National Monument	SC	C		N/A	N/A		
Gateway National Recreation Area	NY	C	+	25.0	20000	+	
George Washington Birthplace N M	VA	P		2.0	N/A		
Gulf Islands National Seashore	FL MS	C	+	76.0	81946	+	
Padre Island National Seashore	TX	C		66.5	33550	+	
Timucuan Ecological & Historic Preserve	FL	P	+	N/A	34641	+	
Virgin Islands National Park	VI	C	+	36.0	5310		+

Pacific Park Units

Park	State	Jurisdiction	Commercial fishing authorized	Miles	Acres	Shark fishing	Nursery
Aniakchak National Monument & Preserve	AK	P	+	60.0	N/A		
Bering Land Bridge National Park	AK	P		400.0	60000		
Cabrillo National Monument	CA	E		1.0	300		
Channel Islands National Park	CA	Other	+	175.2	125000	+	
Fort Point National Historic Site	CA	C		1.0	N/A	+	
Glacier Bay National Park & Preserve	AK	P	+	900.0	550000		
Golden Gate National Recreation Area	CA	P	+	30.0	4628	+	
Kaloko-Honokohau National Historic Park	HI	P		1.7	500		
Katmai National Park & Preserve	AK	C	+	390.0	N/A		
Kenai Fjords National Park	AK	P	+	430.0	N/A	+	
Lake Clark National Park & Preserve	AK	C		120.0	N/A		
National Park of American Samoa	SA	Other		17.0	3000		
Olympic National Park	WA	E	+	50.0	N/A		
Point Reyes National Seashore	CA	C		180.0	4001	+	
Pu'uhonua o Honaunau National Historic Park	HI	N/A		1.4	N/A		
Pu'ukohola Heiau National Historic Site	HI	P		1.0	1		
Redwood National Park	CA	C	+	36.0	5694		
San Juan Island NHP	WA	P		6.1	78		
Santa Monica Mountains NRA	CA	C		46.0	1413	+	
Sitka NHP	AK	P		0.7	50		
War in the Pacific NHP	GU	C	+	4.0	1002		
Wrangell-St. Elias National Park & Preserve	AK	P	+	115.0	545		



As the nation's principal conservation agency, the Department of the Interior has the responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The Department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-1160 October 1996